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THE FERNS (PTERIDOPHYTA) OF THE KUINDERBOS (THE NETHERLANDS). THE ESTABLISHMENT OF 23 SPECIES IN A PLANTED FOREST

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SUMMARY

In the Kuinderbos forestry (1100 ha) planted 26–31 years ago in the N.E. Polder an ecological investigation of the ferns was carried out in 1979. The 23 species found represent nearly the complete Dutch fern flora; two species are new to The Netherlands. The establishment of so many species reflects the great dispersal capacity of the group and seems to be evoked by the presence of a great length of ditches (240 km), opening various types of soil under different tree species.

The ditch environment markedly differs from the known habitat of many of the species in NW Europe. Correlations between species and environmental factors (e.g. pH, organic matter, lime content and light intensity) were in good agreement with literature data; their ecological amplitude seems to be widened in this young forest.

1. INTRODUCTION

The well-known rule of Beijerinck (BAAS BECKING 1934) "Everything is everywhere, but the environment selects", leaves time out of consideration. Some phanerogams indeed need a lot of time to establish. Studies in the polders of the former Zuiderzee revealed that new establishments still occur 20–30 years after reclamation (BREMER 1978, NIP-VAN DER VOORT et al. 1979). That the time needed for dispersal and establishment in a new habitat can be short, is often illustrated by euchorous plant species, especially those having spores for propagation. Many species of mosses and ferns can be transported by air over thousands of kms (VAN ZANTEN 1979), while the larger fern spores (25 to 50 μm) can be transported along distances of hundreds of kms effectively. From these observations it can be deduced, that the early establishing mosses, ferns and fungi will more clearly reflect aspects of variation of the environment, than most phanerophytes do (JOENJE & DURING 1977).

2. THE STUDY AREA

The trees of the Kuinderbos (1100 ha) were planted in the period of 1949–1954 in the North Eastern Polder (NOP), reclaimed in 1941–'42 (*fig. 1*). Soil conditions of the plantation are shown in *fig. 1*. Several thousands of years ago the southern part was covered by heathland, forming a podsol profile, later on overgrown by peat bog. Remnants of this peat are found between the podsol-zone and the

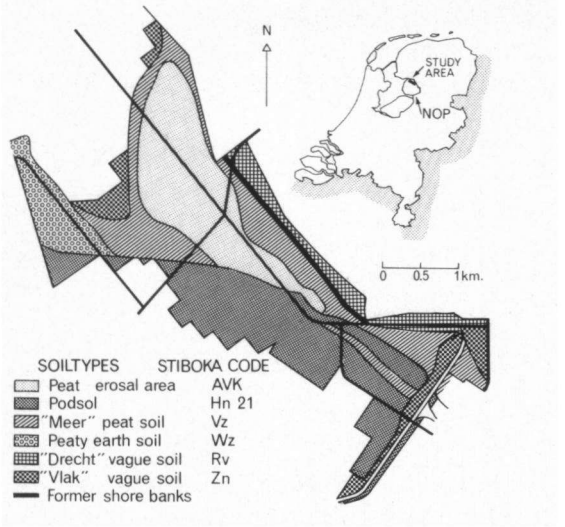

Fig. 1. Soil map of the Kuinderbos forestry (after Stiboka, unpublished). Inset: the study area in the Netherlands.

border of the polder. Here, in the so-called Peat erosal area, the peat partially eroded during the Zuiderzee period (1600–1932) and holes were filled up with a very fine-grained sediment, "Blokzijl"-sand. Nowadays this Peat erosal area comprises a peat area with a variable (20 to 100 cm) layer of Blokzijl sand. Where this layer is less than 40 cm the soil type is called "Meer"-peat soil, and at the transition of forestry and polder we find "Drecht"-vague soil, where acid clay is deposited on top of the peat. At the eastern side of the forest a clay is deposited on top of the podsol: Peaty earth soil. Sandy soils without a profile can be observed at the NW-side of the area and are called "Vlak"-vague soils.

On the different soil types many tree species were planted or sown (*table 1*). Twelve types of plantations are distinguished, some of them more or less restricted to a single soil type, e.g. *Larix leptolepis* on Veld-podsol, *Picea sitchensis* on Peat erosal soil and *Fraxinus excelsior* on Drecht vague soil.

The plantations on most peaty soils were ditched to phreatic levels, 240 km in total, up to a density of 0.7 km.ha^{-1} in the Peat erosal zone. Nowadays the trees consume much water and drainage has become less important, being restricted to the winter half of the year. The depth of the ditches varies from 50 to 150 cm, the width from 75 to 200 cm. The ditches are generally oriented NW to SE.

3. Methods

The 1979 inventory of the ferns in the Kuinderbos comprised all of the 92 plantations and 130 km out of the 240 km of ditches. Stand descriptions of the different fern species included plantation type, position on the ditch slope, inclination, exposition, soil composition (structure and type, lime content, pH)

in the talud. In some plots repeated observations in subsequent years permitted demographic conclusions.

Furthermore data on the saturation deficit and the amount of light reaching the plant were collected on cloudless days in May and August.

Nomenclature of phanerogams and ferns follows HEUKELS & VAN OOSTSTROOM (1977); of *Polystichum setiferum* after LAWALREE (1950)

4. RESULTS

The fern species and a number of environmental characteristics are summarized in *table 1*. Of the 23 fern species, 14 species occur along the ditches in a frequency of over 95%; 5 species were found along ditches in 75–95%, while 3 species can be found equally in and outside the ditch-habitat. Along the ditches the ferns all grow on the slopes, except *Thelypteris palustris*, which grows on the bottom, too.

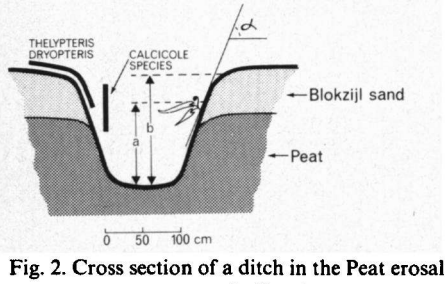

Fig. 2. Cross section of a ditch in the Peat erosal area, showing different habitats.
α – inclination
100 a/b – relative height

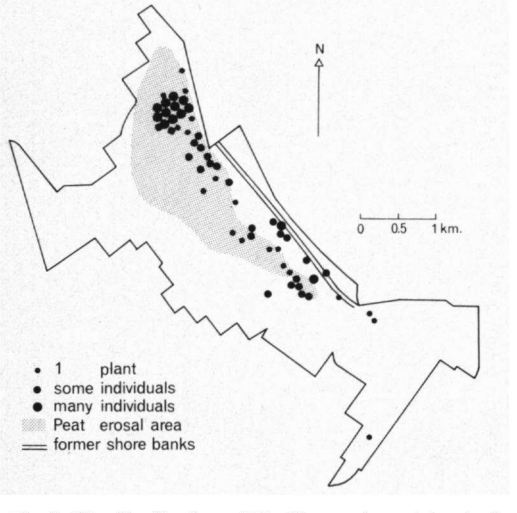

Fig. 3. The distribution of *Phyllites scolopendrium* in the Kuinderbos.

Table 1. Summary of habitat characteristics of all species of ferns in the Kuinderbos forestry. Legend: a: abundant, number of records = individuals, except for *Cystopteris fragilis*, *Phyllites scolependrium* and *Polystichum aculeatum*, + : *over 95% of individuals*, (+): *many individuals*, *i: indifferent*, *Bs: Blokzijl sand*, *s/p: sand and peat*, *p: peat*, *co: coversand*, *cl: clay*, *soil types: cf. fig. 1.* italicized soil types: over 95% of individuals, *Ps: Picea sitchensis* dominating, Fr: *Fraxinus excelsior*, Q: *Quercus sp.*, L: *Larix leptolepis*, A: *Alnus glutinosa*. For relative light intensity reaching the plant, inclination and relative heigt (cf. *fig. 2*) range or mean and standard error are given.

	number of individuals	affinity to ditches	soil	soil type	canopy	light (%)	exposition	inclination (°)	relative height (%)
Athyrium filix-femina	a	(+)	i	i (Hn21)	i	.	.	.	.
Dryopteris dilatata	a	i	i	i	i	.	.	.	.
Dryopteris filix-mas	a	i	i	i	i	.	.	.	.
Dryopteris carthusiana	a	i	i	i	i	.	i	.	.
Asplenium adiantum-nigrum	1	+	BS	*AVK*	PS	0.6	NE	70	60
Asplenium trichomanes ('78 + '79)	11	+	Bs	AVK	Ps	4–77	i	73 ± 9	33–75
Asplenium viride	1	+	Bs	*AVK*	Ps	.	NE	90	37
Cyrtomium falcatum	1	+	Bs	AVK	Ps, Q	.	SW	.	.
Cystopteris fragilis	7	+	Bs	*AVK*	Ps	6 ± 8	i	60 ± 25	41 ± 19
Phyllites scolopendrium	655	+	Bs	*AVK*	*Ps*, Q, Fr	4.5 ± 4	Sw	62 ± 19	54 ± 22
Polystichum aculeatum	91	+	Bs	*AVK*	*PS*, Q	2.3 ± 1.5	NE	58 ± 14	48 ± 24
Polystichum lonchites	2	+	Bs	*AVK*	Fr	.	Ne, SW	62–85	22–86
Polystichum setiferum	16	+	Bs	AVK	*Ps*, Fr	.	.	56 ± 13	49 ± 26
Thelypteris robertiana	3	+	Bs	AVK	*PS*, Q	.	NE, SW	65–70	50–77
Dryopteris cristata	300	(+)	s/p	Vz(AVK)	Fr, Q	.	.	.	.
Thelypteris dryopteris	419	(+)	s/p	AVK(Vz)	Ps	6 ± 3	i	.	.
Thelypteris palustris	22	(+)	s/p	AVK, Vz	*PS*, Q	.	.	.	.
Thelypteris phegopteris	3	+	p	*Vz*	Ps	.	SW	0–50	0–100
Blechnum spicant	3	+	p	*Vz*	Ps, Fr.	.	W	20–80	20–50
Osmunda regalis	2	+	p	Rv, Vz	Ps	.	NE, W	50	44–100
Polypodium vulgare	79	(+)	co	Hn21(AVK)	L, Q, F	.	NE	.	.
Pteridium aquilinum	1	+	cl	*Rv*	A	.	E	.	.
Dryopteris borreri*)	.	.	.	.	.	.	.	.	.

*) This species, recently verified at the Rijksherbarium, Leiden, was not further considered in this study.

On the slopes different soil types are exposed. Ten species are more or less restricted to the Peat erosal area with relatively thick layers of calcareous Blokzijl-sand (*fig. 2* and *table 1*); these ferns can be regarded as calcicole. The distribution of one of these species, *Phyllites scolopendrium*, is depicted in *fig. 3*. The calcicole species mainly grow under a canopee of Sitka spruce, except for *Polystichum lonchites*, which occurs under *Fraxinus*.

As to exposition, *Polystichum aculeatum* prefers a NE-facing surface, whereas *Phyllites scolopendrium* prefers a SW-exposition. *Asplenium trichomanes* and *Polystichum setiferum* being indifferent with respect to exposition, do diverge in inclination, the former occurring on the steepest slopes. The same holds for *Thelypteris robertiana* and *Cystopteris fragilis*. *Polystichum aculeatum* occurs in the darkest habitats, *Cystopteris fragilis* under lighter conditions (*table 1*).

Three species occurring mainly on peat, can be regarded as acidophilous: *Thelypteris phegopteris*, *Osmunda regalis* and *Blechnum spicant*. Due to the low number of individuals, no further differentiation in habitat can be discerned.

Three other species are intermediate between the calcicoles and acidophylic group, i.e. *Thelypteris dryopteris*, *Dryopteris cristata* and *Thelypteris palustris*. The latter is more or less restricted to the Peat erosal area and often found on the bottom of the ditches. *T. dryopteris* is restricted to Sitka spruce and prefers the older and relatively open plantations. *D. cristata* occurs mainly on the "Meer" peat soil, avoiding the Sitka stands, but preferring *Quercus* and *Fraxinus*.

5. DISCUSSION

The Kuinderbos appears to harbour a great number of fern species. With 23 species found in 1979, it is by far the most fern-rich area in the Netherlands (BREMER 1980a). This diversity seems to reflect the great dispersal capacity of the ferns as a group. New to the Netherlands are *Polystichum lonchitis* and *Asplenium viride* (BREMER 1980b). They may have come from Great Britain, transported by western winds. *Polystichum setiferum* was not observed in the Netherlands until recently (DE GRAAF & HEUKELS 1979); the spores travelled at least a hundred kms, from the nearestby station in Germany or from the Netherlands province of Limburg (*fig. 1*), or came from Great Britain as well.

Thelypteris phegopteris, *Cystopteris fragilis*, *Thelypteris robertiana*, *Polystichum aculeatum*, too, had to cover a distance of more than 50 kms. However, the spores of these rare immigrants and of those from nearby provenances have about the same size (BREMER 1980a).

After dispersal many species found a suitable environment to establish and 18 of them were found sporulating. In the study area numerous combinations of soil type and plantation occur. The highest species diversity is found in the Peat erosal area (19 spp.) especially when combined with a Sitka spruce plantation (17 spp.). Here the ditches expose the lime-rich Blokzijl sand and the spruce offer a suitable micro climate. Ten species mainly occur on the Blokzijl sand and most of them are known as calcicoles (ELLENBERG 1974, HEGI 1965, WEEVERS et al. 1948).

It is remarkable, that eight of the calcicole species of the Kuinderbos-grounds

normally grow on walls and in rock-crevices. Of these, *Asplenium adiantum-nigrum*, *A. trichomanes*, *Cyrtomium falcatum*, *Phyllites scolopendrium* and *Thelypteris robertiana* have hardly ever been found terrestrially in the Netherlands (WEEVERS et al. 1948). Apparently the steep slope of the ditches with the sandy top layer sufficiently resembles their normal habitat.

Of the other species, normally occurring in habitats rather deviating from the ditch habitats, *Cystopteris fragilis* (hollow roads) and *Thelypteris phegopteris* (rivulet banks) can be mentioned. The related *T. dryopteris* prefers Sitka as a cover, but is normally mentioned as a characteristic species of the *Stellario-Carpinetum* (WESTHOFF & DEN HELD 1969). In Central Europe it is found in moist deciduous and coniferous forests (HEGI 1965). In the United States it does grow in natural Sitka forests (NEILAND 1971, FONDA 1974).

Thelypteris palustris and *Dryopteris cristata* are known as species of peaty reedland and wet forest (WEEVERS et al. 1948, HEUKELS & VAN OOSTSTROOM 1977). In the Kuinderbos they grow in nearly all plantation types and on all soil types.

A general conclusion is, that the fern flora or the Kuinderbos consists of an unusual combination of species, in view of their known habitats. They all seem to have widened their ecological amplitude (WEEVERS et al. 1948). This may reflect some combination of a very suitable "fern-environment" with respect to soil conditions and micro climate, as well as the great long-distance dispersal capacity of ferns as a group.

Euchorous dispersal of both phanerogams and cryptogams into new polders is well-known and documented by various authors (FEEKES 1936, BAKKER & VAN DER ZWEEP 1957, JOENJE & DURING 1977, JOENJE 1978). In nearly all cases the dispersal is concluded from actual establishments; this however, only measures the amount of suitable environment. Thus the establishment of the many species of ferns and other cryptogams in the Kuinderbos, which is not encountered elsewhere most probably lies in the special environmental conditions, i.e. the partly eroded pleistocene landscape. The leached sands with a low pH and nutrient poor peat-deposits, partly enriched with marine sands, rich in lime, now provide a variegated environment not met in other embankments.

When nature management i.e. forestry measures, are planned in accordance with these primary conditions, the Kuinderbos area will continue to provide other establishments of rare and interesting species.

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